# Designing Appropriate Assistive Technology for Home Users: *Developing Dependable Networks*

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*A Paper Prepared for and Presented at*

*"Inclusive Design and Mobility Response in Indoor/Outdoor Public Buildings and Facilities"*

*CIB Working Group W084 – Building Non-Handicapping Environments*

*Viale Marx, 43 – 00137 Roma, Italy,*

*21st and 22nd October 2002*

## *Abstract*

*This paper is concerned with explicating some of the multiple concerns involved in designing appropriate assistive technology in domestic, or home, settings. As society becomes increasingly reliant on computer-based systems, and as domestic settings become increasingly technologised (Dewsbury 2001), the systems themselves have become increasingly complex and the need for dependable systems correspondingly important. Achieving sufficient dependability in these systems, and demonstrating this achievement in a rigorous and convincing manner, appears crucial in moving towards an inclusive Information Society. The paper reflects our interest in making some initial steps towards developing improved means of specifying, designing, assessing, deploying and maintaining complex socio-technical systems in domestic contexts where high dependability is crucial. As computer-based systems and artefacts penetrate more and more into people's everyday lives and homes, the 'design problem' is not so much concerned with the creation of new technical artefacts as it is with their effective and dependable configuration and integration. It is evident that satisfactory resolution of such concerns demands major, interdisciplinary breakthroughs in understanding the development of complex socio-technical systems in domestic environments since inadequate understanding of the context of the lived reality of use and user needs is often a significant cause of lack of dependability. The paper also explores the ongoing DIRC project that, currently, is ethnographically investigating these areas within its Project Activity 'Dependable Ubiquitous Computing In The Home'. Whilst this paper does not attempt to solve all of the presented issues it does aim to illuminate some fields of investigation that might form the basis for future and ongoing research and development agendas for appropriate technological interventions in domestic settings.*

## *Keywords*

*User Centred Design, Assistive Technology, Network Systems, Home Networks, Smart Home, Domotics, Dependability, Home Care, CSCW, Appropriate Design, Technology Design Considerations, Cultural Probes, Ethnography.*

## *Introduction*

> *Dwelling with computers, they become part of the informing environment, like weather, like street sounds. A house that is true to its house nature must have a certain quiet, even stolidness. Through a thousand subtle cues, computers will help turn our houses into homes. Weiser (1996)*

The notable rise in the uptake, usage and general pervasiveness of domestic technology in the last four decades has had considerable, if not predictable, implications for the home occupant (Hindus, 1999, Hindus et al, 2001). Labour saving devices such as vacuum cleaners have enabled people to achieve cleaner households but have not saved domestic labour time, as standards of cleanliness have increased proportionately. There has been also been a blurring of the boundaries of technology within recent years, such that devices that were previously only seen in cars, offices, or hospitals are now finding their way into the average home. The home itself has undergone considerable alteration (Dewsbury et al, 2001, & 2002), not necessarily or only in outward appearance or architectural detail, but in the way that it is used by its occupants (Crabtree et al, 2001). The original design and layout of rooms, for specific and static purposes, has been modified such that there has been a blurring between designated spaces while activities are no longer confined to pre-designated spaces (Junestrand & Tollmar, 1998). Similarly as domestic spaces are created to meet needs of the individual occupiers, these needs are themselves often related to technological developments. The home computer, for example, along with games machines, televisions, videos etc now act as a determinant and identifier of these spaces.

New information and communication technologies, such as the home computer, have enabled the isolated to find friends, the person with speech difficulties to find a voice, the non-communicative to communicate, and the disabled person to be enabled. Clearly technology has empowered a number of people, just as, some suggest, it has the potential to enslave similar numbers. Technology has become part of everyone's life. We accept that it is the norm for a home to have a television, a video, a cooking facility, a bathroom with shower, a stereo system, (or even a home theatre system) a mobile phone, and a personal computer. We are not surprised by houses or cars that have burglar alarms, and often ignore the sounds of these devices. We have clearly become a technologised culture (*see* Dewsbury 2001), relying and accepting the benefits and disadvantages of technology. Although we may embrace it, technology can and often does work against us. Computer users will all recognise the blue screen or the feeling that occurs when the mouse pointer refuses to move any more as the computer has crashed. This usually happens at the worst possible time in the authors' experiences. Cars tend not to start in cold or wet weather, when they are needed most. Technology systems are excellent when they work appropriately but can cause severe misery when they fail to respond in the appropriate or expected manner. It is this issue of dependability and appropriate design that forms the focus of this paper.

We seek to consider and review the role of technology in relation to homes and cover issues concerning assistive technology, home automation (smart homes), and telecare in relation to developing a potential model of 'appropriate' technology specification. Of course, delineating the

parameters of appropriate design and determining how appropriate design might be achieved is an enterprise fraught with difficulty. We discuss a number of emerging features of appropriate design for technologies in domestic environments. Overall, appropriateness is based on, built around, developing interactions between users and the technology. These interactions are subject to various general kinds of reconfiguration and change such as evolving social demands and uses of domestic space; changes in technology usage and development as well as specific aspects of appropriateness related to the particular application or function and issues such as privacy or security.

Any attempt to examine home technology and appropriate design is fraught with difficulty as there are countless levels to the definition of what constitutes appropriate design. This paper attempts to highlight some of the most important issues around installing home technology, appropriate design and framing it within a context of dependability. The paper attempts to draw together disparate ideas from Computer Supported Cooperative Work (CSCW), Human Computer Interaction (HCI), Sociology, Engineering, and Psychology in an attempt to examine the relevance of these notions to the area of appropriate design and dependable systems. We discuss a number of emerging features of appropriate design for technologies in domestic environments. Overall, appropriateness is based on, built around, developing interactions between users and the technology. These interactions are subject to various general kinds of reconfiguration and change such as evolving social demands and uses of domestic space; changes in technology usage and development as well as specific aspects of appropriateness related to the particular application or function and issues such as privacy or security.

We considers technology in the home, smart homes and their potential application as well as the problems of achieving a dependable system that is appropriate to the needs of users. We provide a review of different approaches to the design of technology for domestic settings and a consideration of these approaches in terms of various notions of appropriate and dependable design. Dependability - as that part of a system that reliance can be placed on any service delivered is clearly critical to the development of robust, reliable and trustworthy systems. Again, however, 'dependability' can be viewed in different ways. Dependability issues often include safety, security, reliability and usability.

This paper considers the work currently being undertaken by Lancaster University in the DIRC project (http://www.dirc.org.uk) in relation to domestic technologies and asserts a model for considering dependability issues within whole house systems. DIRC is an UK project that is considering the role of dependability in systems (in the broadest sense) and is specifically looking at issues relating to assistive technology within the home.

## *Home Technology and the Networked Home*

> *It could be argued that smart systems for residential housing add some intrinsic value through incorporation of increased security, safety, convenience and comfort within the home. Petersen et al, (2001, 522)*

The pervasiveness of home technology has lead to an upsurge in the use of home networking. The increase in home networking is having great effects on the lives of older and disabled people. This socio-technical system allows a residence to be connected to the outside world through a residential gateway that passes information down an ISDN or DSL phone line. Home networking allows the home to become a fully connected entity that can be controlled externally as well as internally. The increase

in telemedicine and telecare as initiatives that extend beyond the conceptual into the real world are only possible through the home network. The smart home, (automated home, domotic, intelligent home etc.), in which devices are interconnected (networked) and programmed to act in predetermined patterns, has been extended through the home network to allow external monitoring and control. For a disabled or older person, home networking offers the potential for their home to be programmed to monitor and respond to cues whilst allowing the occupant the safety and reassurance that should a fault develop or a problem occur within their home then the correct people will be informed by the technology within the home network. The home network has negative as well as positive aspects to it. One difficulty is caused by the ISDN/DSL connection which remains in the state of "always-on". This denotes the permanently connected home could potentially face threats from external hackers. Moreover, this "always-on" connection means that the system is constantly open to potential viruses and other attacks by malevolent programmers. This necessitates that the home network should have a suitable virus checker and a firewall to deter hackers.

The technological home of today and tomorrow embraces technology within its structure. Venkatesh and Mazumdar (1999) and Venkatesh et al (2001a & 2001b) considers that the role of technology is integrated into other living spaces, such as physical, social to make up the whole notion of home. Within Venkatesh and Mazumdar 's model, technology (technological space) interacts with all other spaces. The model does provide an excellent framework to consider the importance of technological innovation within the home. As the 21st Century commences, technology can be used to enable people to derive an improved quality of life through the appropriate use of advanced technology. The home network can allow isolated individuals to retain contact with the world around them as well as allow for external monitoring of people who require this service.

A clear and practical use of technology is the introduction of home networks, involving smart homes, telecare, telehealth and telemedicine, to allow people with possible illnesses or disabilities to retain a quality of life within their own home. Home networks and smart homes can assist in undertaking operational tasks, telecare enables a person to remotely assessed and monitored by medical staff and telemedicine allows a full virtual medical service to be brought into the home of the person requiring the specialist service. The application of technology from the medical field into the home raises a number of interesting issues that will be considered below. The role of technology is within the home is extensive and the application of this technology extends into a number of areas which are enhanced by home networks. The home network appears to be a manifestation of the twenty first century, as computer operating systems are adopting protocols that should easily interface with home networking products, and manufacturers are redesigning their products to allow for greater standardisation and interoperability.

## *Telecare, Telehealth Technology and Residential Gateways*

> *The current offerings in Home Automation are both exciting and frightening. The means to automatically manage almost anything that uses electricity is available today. Until security is taken seriously in these systems, though, there is great risk in doing so. The favourable (sic) trend of making high tech devices easy to use is resulting in a diminished focus on reliability and safety. Designers of these solutions need to think about security at every level and stop considering it to be "Somebody else's problem". Brodeur, M J. (2001)*

The appropriate design of home technology requires that the designer make choices concerning the most appropriate, available technology that is cost effective (Edge et al, 2000, Dewsbury and Edge, 2001). In fact, there are an almost infinite number of technologies available for older and disabled people.

> *Technological advances are a major influence upon increasing longevity and improving, in a sustainable manner, the quality of life enjoyed by an ageing population. Kinder (2000, 72)*

Telecare systems,for example, are still in their infancy and there are few proprietary systems available on the market at this time (Anchor Trust 1999, Porteus and Brownsell 2000, Tang 2000, Fisk 2001a, Fisk 2001b). Systems are usually designed using one-off AT devices such as blood pressure monitors and configured into a standard systems such as a smart house system or a call system. Both telehealth and telecare systems rely on the use of the Internet or telephone lines as a means transferring information from the source (the house) to the receiver (the doctor/nurse etc). This relies on a Residential Gateway (RG) (also known as routers) and a number of security issues surround the use of this form of data transference. Herzog and Shahmehri (2001) demonstrate that within the e-service 'Monitor and Control' the residential gateway on the home net are accessible by e service clients via the internet only after authorisation at the system service provider. The RGs are configured to reject all other service traffic than that from the system service provider, yet they allow ftp download and web browsing from the home net without system service provider interference. There are also a number of ethical problems associated with RGs. These concern the appropriateness of data transmission, what is ethically acceptable to be transferred to external sources. There is little control over the data that leaves the home; there is little control over who has access to this data and what is done with the transferred data. The Data Protection Act does not cover this form of data transference as it is still in its infancy.

Davies and Raverdy (2000) contend that future home networks will consist of multiple networking and platform technologies integrated through a series of gateways and shared devices. They go on to suggest that it is for developers to build heterogeneous middleware platforms that are irrespective of the operating system used. This does bode the question that the more heterogeneous middleware platforms there are which are working irrespective of operating systems there are, the more potential security threats and more holes that will be required to be filled leading to a possible unstable whole system. Wang et al (2000a) contend that there is a need to monitor device configurations to detect abnormal patterns. Wang et al (2000b) suggest that the home networking environment is more heterogeneous and dynamic than traditional network environments as consumer devices are likely to be connected to different networks, running different protocols and madder by different manufacturers. Jonietz (2002) illustrates that technology might be based on self-organising networks in which devices would automatically recognise what they are and what they should do with the information, "every element automatically recognizes every other element. Without any outside help, the devices must then determine how to get data where it needs to go" (Jonietz 2002).

## *Dependability*

> *The trick in designing technology is to provide situations that minimize error, that minimize the impact of error, and that maximize the chance of discovering error once it has been committed. The humancentered way. Norman (1993, 13)*

The Issue of systems dependability is critical to the development of appropriate technology solutions, which are robust, and meet needs of users (Edge et al, 2000, Dewsbury et al, 2001 & 2002). Systems must be appropriate for the user. Clearly, if design is to reflect real need then two preconditions need to be met. Firstly that the design is dependable and second that the needs are truly reflected in the design. Dependability is defined by Brian Randell (2000) in the following manner:

> *A system is dependable to the extent to which its operation is free of failures. Then Dependability can be defined as that property of a computer system such that reliance can justifiably be placed on the service it delivers.*

The notion of free of failures is complex in that some failures might be built into the programme as part of the design, where as other failures might be unforeseen and a consequence of unpredicted circumstances. It is useful to consider that there is a difference between failures and errors. Randell (2000) draws a distinction in the following manner:

> *A system failure occurs when the delivered service deviates from fulfilling the system function, the latter being what the system is aimed at. An error is that part of the system state which is liable to lead to subsequent failure: an error affecting the service is an indication that a failure occurs or has occurred. The adjudged or hypothesized cause of an error is a fault.*

Therefore, for a system failure to have occurred, an error or a number of errors, or deviations must have occurred somewhere within the system. It is useful to note that the system in question does not necessarily need to be software or hardware; it is as applicable to human/mechanical error and computer interaction.

In order for a home system of networked devices to meet the needs of older or disabled people effectively, system failures need to be minimised and controlled. This paper suggests that system failures are more than just simple acclimations of device errors; instead there is a complexity to the failure patterns within home systems. The pattern of failure is synonymous with lack of good design protocol (Dewsbury 2001, Dewsbury et al 2001). There is a simple, almost linear, process to designing appropriate technological home solutions, allowing for iterations of the design to be undertaken throughout the process. Hence, in order to achieve a successful design, the designer is required to consider how the technology is to be used in the home, who is using it, in what ways will it be misused etc, based on the needs of the occupants. Then they are required to consider issues of dependability in relation to the most appropriate system to meet the needs with the most robust architecture to meet cost/benefit/user needs/availability requirements. The designer is further required to consider how each device is to be used and whether this is the most appropriate device based on the needs of the user(s). At this point, a systems design can be considered and the perspectives of the different users sought. The system can be redesigned to meet the real needs of the user. Finally the designer reviews the design and reconsiders aspects of safety, reliability and appropriate usage of the system before progressing to the final design architecture.

The designer undertakes what appears to be a standard process, yet within this process there are a number of non-linear elements that are required to be considered. The eleven main features of the complex scenario are:

*Affordability*
*Configurationality*
*Functionality*
*Interactivity*

*Interoperability*
*Repairability*
*Personalisation*
*Reliability and susceptibility to breakdown*
*Technological*
*Usability*
*Utility*

The eleven elements are intertwined in one another and are not static entities. Although each element is seeming insular and a part of a linear pattern they are in fact intermeshed elements. This elemental network provides the infrastructure for system failures and system security. Two elements stand out as cross elemental, namely safety and sensitivity. The issue of safety cuts through hardware and software dimensions as well as having validity within the human dimension. Systems are required to be safe, to provide a safe environment, to work together safely, to enhance personal safety and to be maintained safely. Similarly, any design requires sensitivity to personal and physical aspects and their relationship to technology, as well as sensitivity relating to how devices function. The correct pressure applied to the control unit should start or stop an operation within the home; too little or too much should not have undesired results. Devices themselves are sensitive and need to be set to the appropriate levels, just as configuring more than one type of system requires sensitivity to each protocol to avoid unwanted results or system failures.

## *The User's Experience*

*Technologies can be understood as materials whose stability relies upon the continuous reproduction of their meaning and usefulness in practice. Suchman, (2002, 264)*

Although lip service is often paid to the *'adding the user into the design'* an essential feature of good design **is** to know as much as possible about the person(s) for whom the design is being done. In the case of older or disabled people, the easiest option is to talk with the appointed or informal carers to find out what they might consider the needs of the person(s) to be. Clearly this might yield some useful data but the disabled or older person(s) should always be the primary target. Their views combined with the views of other carers and stakeholders should provide a useful platform from which the design can be launched.

Methodologically there are a number of problems with finding the most appropriate form of obtaining the views of the relevant parties. Standard interviewing will yield a certain amount of information; focus groups might also provide a useful information source in the short term. The Computing Department at Lancaster University in conjunction with the Psychology Department at the University of York are currently looking at issues of dependability within the DIRC (Dependability Interdisciplinary Research Collaboration) Project Activity (PA7) entitled *'Dependable Ubiquitous Computing In The Home'*. DIRC is a UK project that is considering the role of dependability in systems (in the broadest sense) and is specifically looking at issues relating to assistive technology within the home. It considers how systems failures occur, what is a fault and what is an error; how systems can be made more reliable and safer; how issues of timeliness, structure, responsibility, diversity, risk and maintainability are addressed within the areas of advanced home technologies

The types of systems that we are focusing on here are so-called assistive technologies, by which we mean technologies that enable and support elderly and disabled people to live independently. These have to be dependable as the users may not be able to cope without them and have to

be designed for users whose capabilities may be impaired in a variety of different ways. We believe that if these systems are to be both dependable and usable then we need to have a thorough understanding of users and the environment where these systems may be installed. Therefore, the first stage of the project is a collaborative activity with a group of elderly people to help us understand how they might use assistive technologies and to get their opinions as to what technologies would and would not be useful.

The primary objective of this activity is to investigate the problems of ensuring that computer-based systems that are installed in people's homes are dependable. This type of system is quite different from organisational computer systems because the operating environment of the system can't be controlled, users are incredibly diverse and users don't have specialised training. Consequently dependability is paramount.

The study is using ethnomethodologically informed ethnographic design as direct input into the design process (Rouncefield et al, 1997, Sommerville et al, 1992). Ethnographic studies (Hughes et al 1993) claim to provide a 'sensitising' to the 'real world', 'real time' character and context of everyday life and the facilitation of what Anderson (1994) calls 'the play of possibilities for design'. As Garfinkel states ethnomethodology seeks

> *'to treat practical activities, practical circumstances, and practical .. reasoning as topics of empirical study, and by paying to the most commonplace activities of daily life the attention usually accorded extraordinary events, seeks to learn about them as phenomena in their own right' (Garfinkel 1967)*

As part of this project we are undertaking 'lightweight' ethnographic studies with residents in their own homes.

One way in which we have attempted to increase the repertoire of available techniques is through the employment and adaption of 'cultural probes' in which a number of common items are given to older people to provoke inspirational and diverse responses. 'Cultural Probes' (Gaver et al, 1999), originating in the traditions of artist–designers rather than science and engineering, and deployed in a number of innovative design projects (e.g. the Presence project) may prove a way of supplementing ethnographic investigations. We use 'cultural probes' (cameras, diaries, maps, Dictaphones, photo-albums, postcards etc) in the project, as a way of uncovering information from people that are difficult to research by other means and as a way of prompting responses to users emotional, aesthetic, and social values and habits. The probes furthermore provide an engaging and effective way to open an interesting dialogue with users (Kember et al, 2002). Through the use of the probes an understanding of how older people relate to technology can be uncovered. The cultural probes being used in the study are specially chosen items that can be used by the older people.

The probes have elicited a wide variety of responses but have enabled the research team to determine some of the most common areas of design failures within the respondents' homes. For example, a number of respondents use the telephone as their only means of communication and a significant number rely on a landline-dedicated phone situated in the living room. This would normally suffice, yet, when a person is living alone or as the main carer of another person who might be severely infirm then the necessity to have a telephone upstairs becomes a real issue. Similarly traditionally, we consider standard tasks such as undertaking the weekly wash as a simple exercise which can be done at our convenience, yet for older people this is not the case as this task (as with most other tasks) there is a necessity to schedule this event into the week as the whole day could be taken up doing it. The scenario in some houses is get the washing

together upstairs; rest; move washing to top of stairs; rest; move washing down the stairs; rest, move washing to sitting room or washing machine; rest; programme washing machine and start it; rest; rest; rest; rest; put washing on line; rest; collect dry washing together; rest; move dry washing to bottom of stairs; rest etc. Hence simple tasks become complex adventures. Through the use of cultural probes the situated activities and organised events through which technology interfaces with the person can be truly explored. The probes act to inform us of how people relate to technology, use technology, worry about technology as well as highlighting areas of difficulty experienced within the person's life. The probes also allow us to find out about life patterns such as who visits the person, what would the most like to be able to do etc. Taken as a whole, the material gathered provides a clear snapshot of a person's life that can be complimented by interview material and other data gathering techniques.

Translating the results of the cultural probes into technology recommendations is also straightforward as the recommendations are already given through the work with the probes. Already, the probes have alerted the team to the differing levels of expectation that people have about technology as well as the differing dependency that people have on technology. The team has also been acutely aware of the lack of understanding and utility of much of the technology that people have in their own homes. Few of the respondents were able to programme their videos, apart from switching on record as they left the house and recording the whole evenings programmes. Many respondents were happy with technology that they couldn't work or wouldn't use, based on the assumption that it was supposed to be good for them.

The eleven elements outlined above have been illuminated through the use of the probes. Activity centres are also becoming clear; the primary centre appears to be the chair nearest the television in the living room when a significant number of single participants spend the majority of their time. The telephone, cooker, washing machine, bedroom, and bathroom are also centres of activity. Many of these areas are also communication and coordination centres (Crabtree et al, 2001) and a series of patterns of activity are being built through the use of the cultural probes.

The eclectic approach adopted by this project attempts to meet some of the ethical and moral dilemmas through careful involvement and acknowledgement of users in the design process. One particular technical concern, perhaps a dominant if unusual concern for a research project, is that of dependability and associated issues of diversity, responsibility and timeliness. Given the domestic setting it is imperative that technologies designed for the setting are reliable and dependable. Sidsel Bjørneby (2000, 37) notes that the reliability of the technology is essential. Just as technology can enable it can equally be the cause of disablement and low self-concept. In amongst the technical challenges are other issues concerning the location of the interface, the generalisability of design solutions, the transfer of skills to real world situations, and support for independent living in the community. These challenges highlight some of the moral and ethical components of the design enterprise, in particular the need to carefully think through and balance issues of 'empowerment' and 'dependence'.

# *Conclusion*

> *The Internet-connected Electrolux ScreenFridge, the NCR Microwave Bank and the new AutoPC appear to be primitive first steps in the direction of pervasive computing. If these efforts sound a bit outlandish, there's a good reason: the devices are solutions in search of a problem. Huang et al (1999)*

The paper has considered technology in the home, smart homes and their potential application and the problems of achieving a dependable system that is appropriate to the needs of users. We have provided a review of different approaches to the design of technology for domestic settings and a consideration of these approaches in terms of various notions of appropriate and dependable design. Dependability - as that part of a system that reliance can be placed on any service delivered is clearly critical to the development of robust, reliable and trustworthy systems. Again, however, 'dependability' can be viewed in different ways. Dependability issues often include safety, security, reliability and usability.

> *The theme of dependability reflects wider concerns about the reliability, security and trustworthiness of computer systems. Society's dependence on computer-based systems continues to increase, while the systems themselves -embracing humans, computers and engineered systems — become ever more complex. These trends coincide with pressure for systems to be brought to market faster and at lower (and more predictable) cost. Achieving sufficient dependability in these systems, and demonstrating this achievement in a rigorous and convincing manner, is of crucial importance to the fabric of the modern Information Society. Proctor and Rouncefield (2001, ii)*

This paper has attempted to outline some the main issues relating to appropriate design of home technology to meet the need of the occupant(s). It has clearly shown that the notion of appropriate is required to be flexible and adaptive to evolving needs. Similarly, appropriate design is required to be reflexive and sensitive to future needs as well as technological needs. Finally, appropriate design is required to meet need through appropriate technology, which in itself is required to be dependable and reliable etc. Overall, appropriate design of home technological solutions required a dependable base set of criteria to be met. Technology is evolving, need is not static, people's relationship to technology in the home is constantly changing and as such it is important to recognise that the determination appropriate technology is malleable and requires system dependability to be reviewed in terms of its current state. There is no single definition or set of guidelines that will or could always be appropriate as technology is constantly changing and the designer of technology is required to be sensitive to the issues of these ebbs and flows as well as possible future issues and trends that might be of relevance. Donald Norman's (1993) words still ring true today….

> *"What can technology do to help?" is almost always the wrong question. (Norman, 1993, 152)*

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Guy And Toni At ENHR Vienna, 2002

Guy Is the one wearing sunglasses!

Guy without Toni At ENHR Vienna, 2002, he seems to be apparently working and he has no sunglasses this time.